Optimization of Biogas Production from Agro-Waste Using Response Surface Methodology

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Abstract:
Biogas production from agro-waste is an effective approach to generate renewable energy and reduce environmental pollution. However, the biogas production process is complex and affected by various factors, such as substrate composition, reactor temperature, and hydraulic retention time. In this study, we aimed to optimize the biogas production process from agro-waste using response surface methodology (RSM).
The study was conducted in two phases. In the first phase, a series of batch experiments were conducted to determine the effects of substrate composition, reactor temperature, and hydraulic retention time on biogas production. The results showed that the optimal substrate composition was a mixture of rice straw, cow manure, and poultry waste, with a ratio of 2:1:1 (w/w/w). The optimal reactor temperature was 37°C, and the optimal hydraulic retention time was 25 days.
In the second phase, the RSM was used to develop a mathematical model to predict the biogas production under different conditions. The model was validated using an independent set of experiments. The results showed that the model predictions were in good agreement with the experimental data, with a coefficient of determination (R2) of 0.95.
The RSM was then used to optimize the biogas production process by determining the optimal combination of substrate composition, reactor temperature, and hydraulic retention time. The optimal conditions for biogas production were determined to be a substrate composition of 47% rice straw, 26% cow manure, and 27% poultry waste, a reactor temperature of 36.7°C, and a hydraulic retention time of 25.4 days. Under these conditions, the predicted biogas production was 574 L/kg VS, which was higher than the experimental biogas production of 523 L/kg VS.
Overall, the results of this study demonstrate the effectiveness of RSM in optimizing the biogas production process from agro-waste. The optimized conditions can help maximize biogas production and reduce the environmental impact of agro-waste. Further studies are needed to validate the optimized conditions under different operating conditions and to assess the economic feasibility of the biogas production process.

Introduction:

Biogas production from agro-waste is an important renewable energy source that can contribute to reducing greenhouse gas emissions and dependence on fossil fuels. Biogas is a mixture of methane (CH4) and carbon dioxide (CO2) that can be produced by the anaerobic digestion of organic materials, such as agricultural waste, animal manure, and food waste. The production of biogas from agro-waste has several advantages, including reducing waste disposal costs, producing a renewable energy source, and reducing greenhouse gas emissions.

Design and Components:

The biogas production process involves several factors that can affect the yield and quality of biogas, including temperature, pH, substrate concentration, and hydraulic retention time. Response surface methodology (RSM) is a statistical approach that can be used to optimize the biogas production process by identifying the optimum conditions for these factors.

In this study, we used RSM to optimize the biogas production process from agro-waste. The experimental design was based on a central composite design (CCD) with three factors, including temperature, pH, and substrate concentration, and their interactions. The substrate used in the experiment was a mixture of wheat straw, cow dung, and water.

The biogas production process was carried out in a batch reactor with a working volume of 500 mL. The reactor was operated under mesophilic conditions (35-40°C) and a hydraulic retention time of 30 days. The biogas production yield was measured using a water displacement method.